

Hard tissue management: osseous access, curettage, biopsy and root isolation

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Following adequate tissue incision, reflection and retraction to expose the surgical site, the next stages of periradicular surgery consist of osseous access through the cortical bone, if still intact, and subsequent removal of any soft tissue lesion surrounding the apical and/or lateral aspects of the associated root to provide unimpeded access to these sites. The soft tissue lesion may on occasions encapsulate foreign material that may perpetuate the lesion if left *in situ*. Any excised lesion should be sent for histopathologic examination to confirm the clinical diagnosis and exclude other pathoses.

Osseous entry

Osseous entry or osteotomy involves removal of cortical and cancellous bone to gain direct access to the apical portion, and the lateral aspects if necessary, of the root or roots of a tooth where periradicular periodontitis is present. There may be fenestration of the root tip through the buccal cortical plate, thus providing instant access. The operator may encounter a periradicular soft tissue lesion that has perforated the cortical plate, in which case curettage of the lesion permits access to the root either without bone removal or minimal extension of the borders of the defect for improved access. Frequently, however, there will be an intact cortical plate that requires removal to expose the surgical site. This is achieved routinely by using rotary instruments.

The main consideration with cutting through bone tissue is the trauma and injury inflicted on the tissue mechanically and particularly by the generation of heat. The tissue may also be more vulnerable to trauma as studies have demonstrated a significant reduction in blood flow to teeth and gingival tissue following the administration of local anesthetic solutions containing the vasoconstrictor adrenaline (1, 2). It is therefore reasonable to postulate that the blood supply to the

periosteum and the cortical bone will be similarly affected, with likely changes in its response to trauma and subsequent healing potential. Furthermore, bone may be more heat sensitive in an ischemic state (3).

Effect of heat

Several studies confirmed that irreversible damage to bone occurred when it was heated to above 56°C and that this temperature was easily exceeded during bone cutting. One study reported a temperature rise to 100°C (4), although this was caused by the use of an oscillating bone saw rather than a small dental bur. Weakening of collagen to hydroxyapatite bonds, denaturation of enzymes such as alkaline phosphatase, osteocyte necrosis and blood flow stasis have all been reported (3, 5–7).

However, it was Eriksson and co-workers' (8–10) in a series of elegant studies that showed the previous underestimation of the temperature at which irreversible damage occurs in bone tissue. In the first study (8), a titanium implant, modified to act as a thermal chamber, was inserted into the tibia of rabbits. Bone was allowed to regrow through a small side hole in the implant and could be viewed through a microscope.

The chamber was then heated for a period of time and the effect on bone, both immediately and over a period of up to 8 weeks, was examined. They initially established that, following a temperature rise to 53°C for 1 min, the blood flow either stopped in some vessels or became sluggish. After 2 days there was complete vascular stasis and subsequently these vessels were slowly replaced with fewer larger vessels. Fat cells were resorbed and bone remodelling only began 3–5 weeks following the injury. They repeated this experiment (9) with different temperatures and time periods. At 50°C for 1 min, or 47°C for 5 min, similar damage occurred, with fat cells gradually replacing the bone tissue present prior to the injury. At 47°C for 1 min, there was still the usual initial vascular response, but little or no gradual replacement of bone with fat cells was seen. They concluded that the threshold for irreversible damage to bone is at the level of 47°C and that injury through heat had to be carefully controlled to avoid impaired bone healing.

In a further study (10), they examined bone regeneration 4 weeks after applying varying temperatures, 50°C, 47°C and 44°C for 1 min. They recorded that the threshold temperature for impaired bone regeneration was between 44°C and 47°C at an exposure time of 1 min. These landmark studies were particularly relevant in the field of implants, where osseointegration is central to the success of these fixtures, but also provided the endodontic surgeon with a clear warning of the risks of overheating the tissues.

There has been a considerable resurgence of interest in the field of heat generation, relating to osseointegrated implant fixture site preparation. The situation is rather different as burs are required to cut a hole into the bony site of some 3–6 mm in diameter and from 8 mm to perhaps 15 mm or more in length. However, the principle of assessing the damage to the cortical plate of bone is the same, and some of the research, therefore, is relevant to surgical endodontics.

Cutting speed

Several histological studies carried out in the 1960s compared the effect of cutting bone (usually the mandibles of dogs) with burs driven by conventional low-speed and the recently introduced high-speed air rotor handpieces, with and without coolant (11–16). They concluded that, overall, high-speed handpieces

were responsible for less or no worse than similar injury. Healing was reported to be more rapid. Moss (11) and Costich et al. (12) also commented on the light pressure needed when using high-speed handpieces to cut bone, the reduced time involved in the procedure and, anecdotally, improved patient acceptance clinically. Recent research in the implant field is generally not so applicable in this area as very low cutting speeds in the region of 2000 r.p.m. are routinely used (17), however, one study (18) did compare the heat generated when preparing implant sites in rabbit tibias with coolant using slow, intermediate and high-speed handpieces. The high-speed range significantly reduced heat production. Abouzgia & Symington (19) however, indicated in an *in vitro* study that drilling at higher speeds and with greater force was responsible for less temperature rise, while Davidson & James (20) recently reported that drill speed, feed rates and drill diameter had the most significant impact on thermal changes.

The main drawback to the use of high-speed handpieces in oral surgery and surgical endodontics is the risk of surgical emphysema from the air/water spray directed at the cutting site. The Impact-Air 45 handpiece was introduced to prevent such an occurrence by providing a coolant only stream directed at the bur tip and exhausting air away from the cutting site (Fig. 1). Subsequently, other handpiece manufacturers have followed suit. The handpiece head was angled at 45° to the shaft of the instrument originally to facilitate access to impacted third molars. This has proven to be a great advantage in surgical endodontics performed with the use of a microscope, as the head can be angled in such a way that the entire cutting portion of the bur is visible to the operator.



Fig. 1. Impact-Air handpiece with 45° angled head.

Coolant

Clearly, water or saline coolants applied directly to the cutting surface of a bur in contact with bone will reduce the temperature rise considerably and limit or prevent permanent damage (6, 11, 14, 15, 21). Bur temperatures, in particular, are significantly lower when water cooled. Recent implant research has indicated that the bur temperature rises rapidly and is higher than the surrounding bone tissue (22). If irrigation is not used, temperatures far in excess of 47°C were noted in seconds in this *in vitro* study.

There is general agreement in the older oral surgery literature and the recent implant literature that liquid coolants are necessary to offset the heat generated by cutting, regardless of speed of cut or pressure exercised. Kerawala et al. (23) expressed concern with temperature rises during use of burs to prepare for osteosynthesis self-tapping screws. They reported that irrigation had the greatest effect on the temperature recorded, with the absence of irrigant resulting in temperatures in excess of 70°C.

Drills used for cutting sites for implant placement use either internal or external irrigation systems, or both (24), but burs used in periradicular surgery may be cooled adequately with a simple external coolant stream. There is no high-speed handpiece and friction grip surgical bur available that uses internal irrigation. Furthermore, the coolant stream must be directed accurately to the cutting surface of the bur and the surgical assistant must position the suction tip in such a way as to remove excess coolant without allowing the coolant stream to be diverted from its path onto the rotating bur. The other advantage of this constant coolant stream is that it assists in removing bone chippings and coagulated blood and debris from the flutes of the bur, thus maintaining an efficient cutting surface and less frictional heat (25).

Ideally the coolant should be sterile water or saline (26), but this has been difficult if not impossible to achieve if the fluid travels through dental unit waterlines. Several workers have reported on the very high colony-forming unit (CFU) count of coolant expressed from water/air syringes and high-speed handpieces, although there appears to be no evidence in the literature of significant infection of the operating site from such coolants (27–29). The site itself, of course, is not sterile, but contaminated with oral bacteria present in the saliva. The recommended alternative involves the

assistant directing sterile coolant from a syringe onto the contact area of bur and bone, but this is difficult to achieve if the operating site is in the posterior portion of the arch.

Recent research has shown, fortunately, that there is now the opportunity to lower the CFU count in dental unit waterlines very significantly, notably by the use of electrochemically activated (30), or super-oxidized, water (31). Other chemical systems have also been advocated to achieve the same goal of removing the bacteria present in the biofilm present on the inner walls of dental unit tubing (32).

Bur design

Moss (11) compared different bur types, as well as investigating the effect of bur speed. He reported that round burs, in particular the No. 6 round bur, caused smaller zones of aseptic necrosis than fissure burs, which Calderwood et al. (13) found cut efficiently along their length, but very poorly on the bur's end surface. However, they obtained the poorest results from diamond burs, where cutting was inefficient and healing delayed. The diamond grit is likely to trap more bone particles and thus increase frictional heat – no author of current texts recommends the use of diamond burs for cutting through the cortical plate during periradicular surgery.

Bur design for surgical use subsequently concentrated on round, steel burs with widely spaced flutes that minimize clogging with bone chips and coagulated debris and reduce vibration. They are recommended for use by various authors (33–35).

A round bur is, however, an unsatisfactory design to resect a root tip and provide a uniplanar surface. Diamond-coated and crosscut fissure burs also produce rougher surfaces than a straight fissure bur (36) and, more recently, a multi-purpose bur (37). An alternative to a round bur is the Lindemann H151 (Brasseler USA, Savannah, GA, USA), a tapered steel surgical bur recommended by several authors (34, 38–40). It has a widely spaced flute design similar to a surgical round bur (Fig. 2), but will produce an acceptable surface of the root tip during resection of the apex, and thus may be used conveniently for both functions. Should a smoother surface be considered necessary, the subsequent use of a tungsten carbide finishing bur has been recommended – a sub-micron diamond-coated finishing bur will actually roughen the surface even more

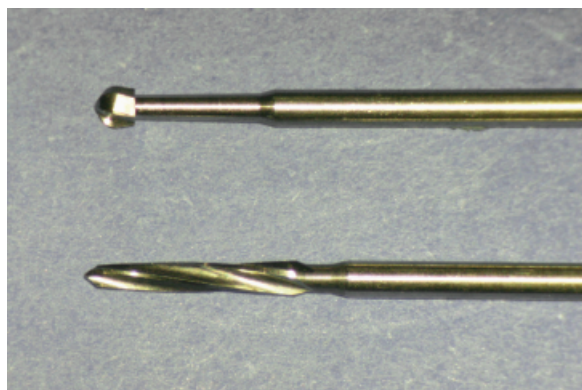


Fig. 2. A surgical round bur and the Lindemann H151 tapered bur. Note the widely spaced flutes to minimize clogging and reduce vibration. Both burs have friction-grip shanks.

(37). It is imperative that this bur, or indeed a round bur, is used with a light brushing or stroking action, running almost parallel to the surface of the cortical plate to maximize the effect of water cooling and reduce friction (41) (Fig. 3). At this angle, the rounded cutting tip is similar in outline to a round bur. Once the cortical bone is cut away and the osteotomy is deepened, the opening should be large enough for the coolant to reach the bur tip when it is angled progressively from the long axis of the cortical plate (Fig. 3).

Although there is no evidence of the effect of used or blunted burs on cutting efficiency and therefore temperature elevation in periradicular surgery, Allan et al. (42) reported recently on the effects of repeated drill use on bone temperature when preparing holes for osteosynthesis self-tapping screws, cut into a cortical plate. There were significant differences in the temperatures generated; the temperature rise when a new drill was used was 7.5°C, compared with a drill used in theatre for an unknown time where the increase was 25°C. As drill cost was low, they recommended single use burs. It would be prudent to follow the same advice for surgical burs in periradicular surgery.

Anatomical structures

The other area of possible trauma relates to damage to the maxillary sinus and the various neurovascular bundles. The structures mainly at risk are the inferior alveolar and mental nerve bundles, although the operator needs to have a good anatomic understanding of the positions of the greater palatine neurovascular bundle, the floor of the nose and the inferior orbital

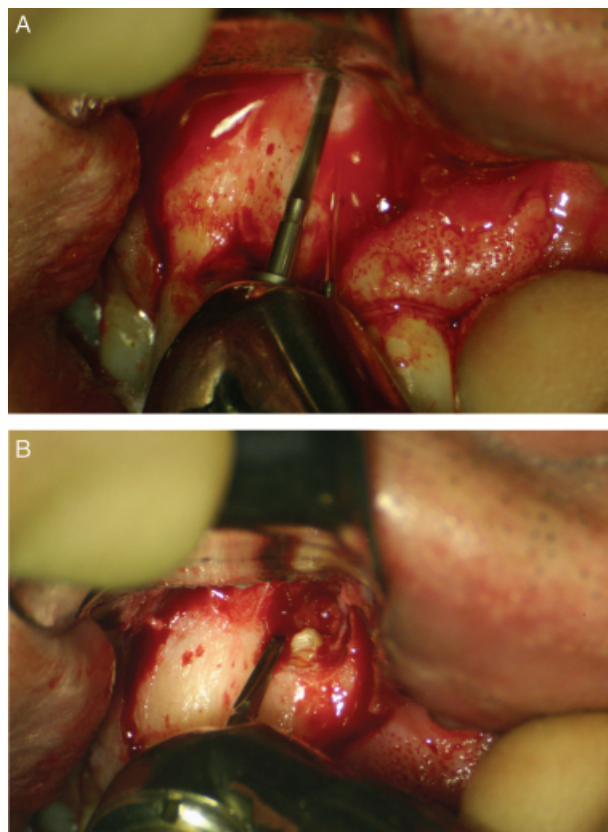


Fig. 3. (A) Lindemann bur almost parallel to buccal alveolar plate – note liquid coolant steam directed at bur tip. (B) Bur now angled in toward right angles to buccal alveolar plate to remove sufficient bone to expose 3–4 mm of root tip.

region. More detailed information can then be gained from relevant radiographs of the site.

Pre-operative periapical radiographs are a pre-requisite to any surgical procedure – a paralleling technique with optimal film or sensor placement must be employed. The tooth length may then be measured on the radiograph and will give a good approximation within a couple of millimeters of the total tooth length. A hand instrument of known length, such as an appropriately long pocket measuring probe, may then be placed over the tooth and the likely position of the root apex estimated. Where the tooth to be treated is multirooted, or the operator suspects there may be a single root with more than one canal present, additional views from an altered horizontal angulation of the tube-head to the mesial or distal, should be exposed. One additional angled view would be the minimum, but for maxillary posterior teeth, both mesial and distal views are considered necessary to gain the maximum information (39).

The surgeon should study closely the preoperative periapical radiographic views, and a dental panoramic tomograph if available, to determine the position of the mandibular and mental canals and the mental foramen. Additional intraoral views with altered vertical alignment will aid in assessing the relationship of the mandibular canal to the root apices in the mandibular posterior region (33).

Provided the surgeon has a good understanding of the anatomy of the surgical site and additional information gleaned from the available radiographs, osseous entry is a safe and predictable procedure. Working with magnification and co-axial lighting will improve visibility significantly and allow accurate and delicate movements and control of high-speed hand-piece and bur to cut precisely.

Technique of bone removal

Site of entry

There may be a perforation of the soft tissue lesion through the buccal plate that facilitates osseous entry and is the optimal starting point (Fig. 4). This is frequently the case where a resurgery procedure is being performed, as persisting disease is present following the initial periradicular surgery procedure. The original osteotomy may never heal and the crypt is filled with granulomatous tissue (Fig. 5). There may be a fenestration whereby the root tip is positioned outside the buccal plate (Fig. 6), or a bony dehiscence that exposes a significant length of the root.

When an intact cortical plate is present, however, locating the root tip may be far more difficult, especially if the surgeon is relatively inexperienced (Fig. 7). If there is a thin layer of the cortex over the buccal aspect of the root, as is often the case with maxillary anterior teeth, the cortical topography may be viewed and palpated and the position of the root accurately ascertained – this necessitates a full muco-periosteal tissue flap or a limited flap design such as the Luebke-Oschenbein where the buccal cortical plate is fully exposed. Several authors have proposed a technique whereby an initial osteotomy access cavity or depression is made and then a small piece of lead sheet from an intraoral radiograph film packet is cut and placed into the site. A periapical radiograph is exposed – it is then usually possible to orientate the position of the root

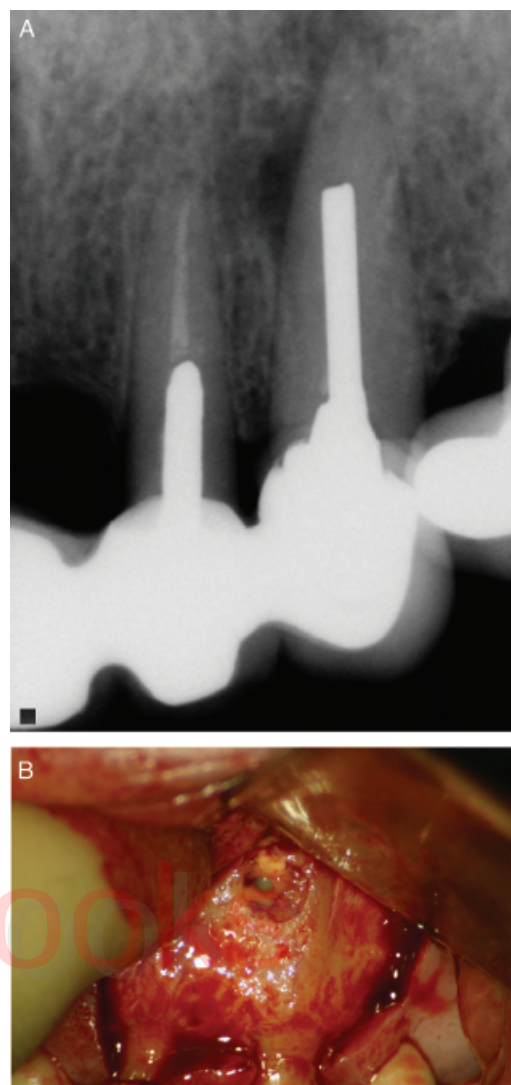


Fig. 4. (A) A lateral lesion, in addition to an apical one, is apparent at the upper left maxillary canine. (B) The soft-tissue lesion has perforated through the buccal cortical plate, aiding location.

apex with the radiopaque marker and extend the osteotomy in the appropriate direction (33, 38–40).

Root tissue is commonly more yellow and darker than adjacent bone. Unlike bone, it is not possible to indent it with a probe, nor does it bleed; it is also surrounded by a periodontal ligament (43). If location and visualization is still a problem, a small amount of 1% methylene blue dye may be placed into the bony crypt on a micro-applicator or brush tip. This material will preferentially stain the periodontal ligament (Fig. 8), thus displaying the root outline more clearly (38–40). The particular aspects of osseous access to different areas of the oral cavity are as discussed below.

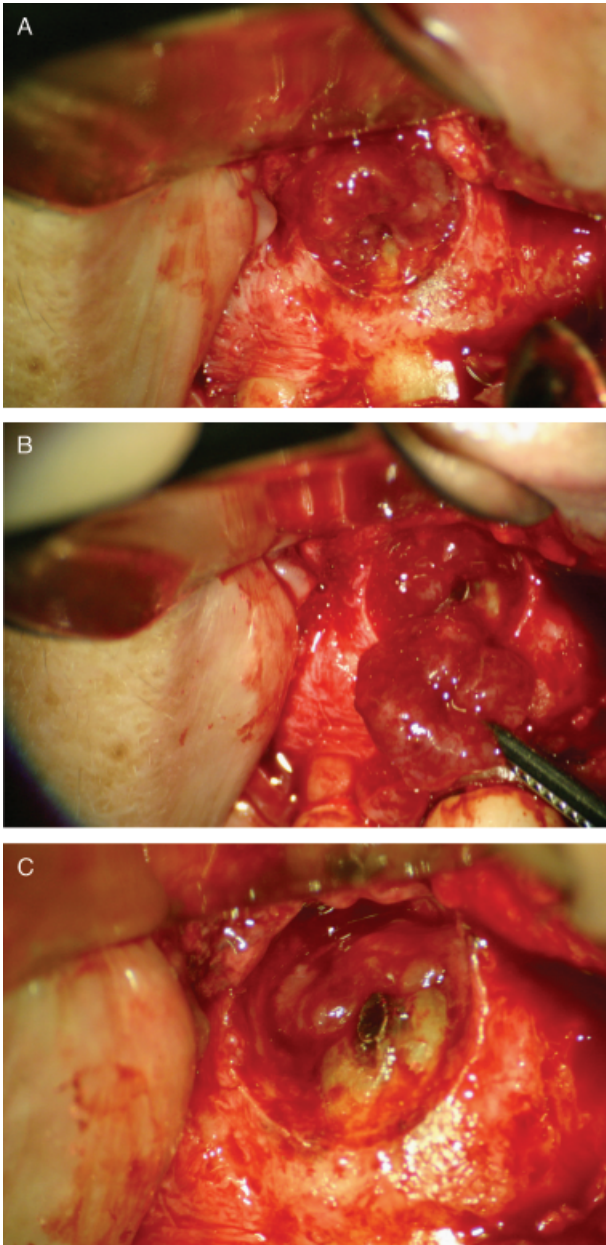


Fig. 5. (A) Large granulomatous lesion associated with failing previous periradicular surgery. (B) Following curettage, lesion being removed from the bony crypt. (C) Exposed root tip – no cutting of bone has been necessary.

Maxillary anterior segment

Access is usually optimal in this area. However, the apices of lateral incisors are often more palatally placed than the adjacent teeth and the cortical topography not so apparent. A deeper osteotomy is required to expose the apices of these teeth. If the incisors or canine are particularly long, the operating site may be close to the



Fig. 6. Mesiobuccal root of tooth #26 fenestrated through buccal plate – there is also granulation tissue around the root.

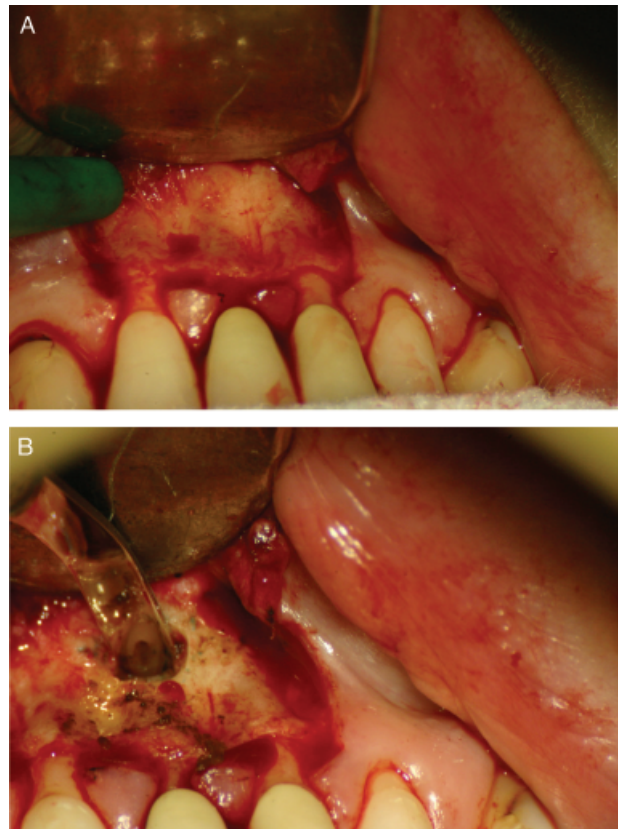


Fig. 7. (A) Intact cortical bone over tooth #31. (B) Following osteotomy, curettage and root resection.

structures of the floor of the nose. In these circumstances, the osteotomy should be cut some 4 mm coronal to the anticipated root apex. The root tip is then cut through and elevated rather than planed away from the apex.

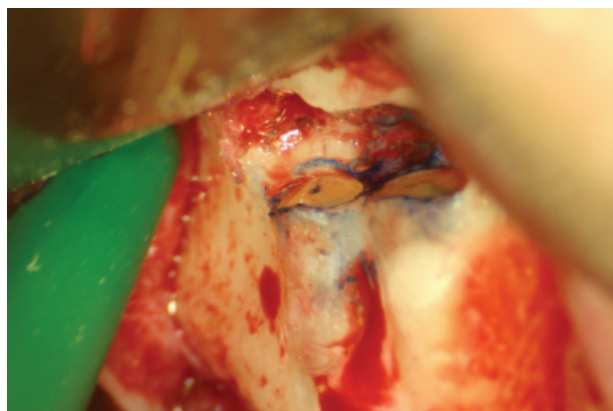


Fig. 8. Methylene blue staining of periodontal ligament and exposed canal – the maxillary right first molar (#16).

Maxillary premolars

The position of the root tip or tips relative to the antrum should be ascertained before the procedure is commenced. Access itself is usually good and the apices close to or perforating the buccal alveolar plate. If the first premolar has two distinct roots, then the osteotomy will need to be larger than usual to allow good access to the palatal root once the buccal root has been more radically resected than is otherwise necessary.

Maxillary molars

Access may be more difficult depending on the size and elasticity of the mouth and lips as well as the muscle attachments in the area, the depth of the vestibule and the proximity of the buccal root tips to the zygomatic process. Once again, the proximity of the maxillary sinus should be assessed, although it is not always possible to anticipate its exposure during surgical access or curettage. The opening will be more mesially positioned as the operator will be viewing the operating site at an angle from the front of the mouth, even with cooperative patient positioning. Care must be taken not to damage the buccal aspect of the root of the tooth mesial to the site. The first molar is obviously more accessible and surgery on a second molar should only be undertaken after considering all the options if access is particularly compromised. With the advent of osseointegrated implants as part of the routine restorative armamentarium, 'heroic' endodontic surgery may be far less predictable than extraction and replacement with an implant fixture.

Should it be necessary to apically resect the palatal root, access will depend on the position of the root tip. If it is close to the buccal roots, then a transantral (44) approach may be undertaken, although a larger opening in the cortical plate will be necessary. The advisability of proceeding if the sinus needs to be perforated is discussed later in the paper.

The alternative is a palatal approach. Although this is not mentioned in many of the current texts, it is described in some detail by Gutmann & Harrison (41) and Arens et al. (45), although the difficulties of such an approach are clearly indicated. A vertical releasing incision is made at the level of the premolars, well away from the greater palatine neurovascular bundle sited between the second and third molars approximately 1 cm superior to the gingival margin. Tissue retraction of the tough mucosa is difficult and there are no obvious surface landmarks on the rough cortical plate to assist orientation. It should only be attempted if there is a moderate-to-deep vaulted palate and requires a skilled and experienced operator and assistant. As above, the alternative of removal and implant placement should be considered.

Mandibular anterior segment

Access may be limited because of a shallow vestibule. The mandibular anterior teeth may also have their root apices positioned lingually. In these cases, access to the root tips is deep and awkward. The direction of the osteotomy has to be slightly coronal rather than directly at right angles.

Mandibular premolars and molars

The depth of the vestibule, together with any prominent muscle attachments, will dictate ease of access to the premolars. The second premolar root tip is easier to locate as it is more buccally placed (41). The incised tissue is reflected more easily over the molar region, but access may be limited by the amount of lip retraction possible.

The major complication of surgery at this site is the proximity of the mental foramen. According to Moiseiwitsch (46), the mental foramen lies usually between the premolars, but could also be adjacent or distal to the second premolar, although there may be slight ethnic differences in position. He also reported that the distance from the CEJ of the mandibular

second premolar to the mental foramen ranged from 8 to 21 mm, and that in 20% of his sample of 105 cadavers, the distance was less than 12 mm. If the foramen does appear to be in close proximity to the root apices of this tooth and a decision is made between surgeon and patient to perform the surgical procedure, the bundle must be identified during tissue elevation and retraction. As the flap is carefully retracted, a thin white line of blanched periosteal tissues will be seen. This will disappear and a narrow dark line become apparent in the region of the foramen as its superior border is exposed (41). Once found, it may be protected with a retractor to eliminate the risk of trauma to it. Kim et al. (39) have suggested that a horizontal groove, approximately 1 mm deep and 3–4 mm long may be cut slightly superior to the foramen, into which the tip of a retractor is firmly located. This refinement should minimize the opportunity of any accidental slippage and consequent damage to the neurovascular bundle.

It is unusual for the inferior alveolar nerve to be in close proximity to the apices of a mandibular first molar tooth – the average distance from the mesial root apex to the superior border of the mandibular canal is almost 6 mm – although it is less to a second mandibular molar (47). A surgical approach in this second molar area is difficult as the external oblique ridge thickens in this site and access to the root apices is very awkward – the distance between the buccal cortical plate and the mesial root apex has been measured at more than 7 mm, whereas it is only slightly more than 4 mm for the first molar (47, 48). It would therefore involve the removal of a considerable amount of cortical and cancellous bone to reach the apices and vision may be severely curtailed. As discussed in the section on maxillary molars, consideration should instead be given to the alternative of intentional replantation or extraction and implant placement, as this site is particularly suitable for such a technique.

For the mandibular first molar, access is still awkward and demanding, with a mesial inclination of resection being used to compensate for the operator's viewing angle, but the osteotomy must still be sufficiently large to allow visualization of the 3–4 mm of the roots. Should the pre-operative radiographs indicate that the mandibular canal is in close proximity to the root tips, resection then involves cutting through the roots at the 3–4 mm level and carefully elevating the apical segments to avoid contact with the inferior alveolar nerve bundle.

Khoury & Hensher (49) described a novel approach to accessing the apical regions of mandibular molars. A bony lid is opened over the roots by outlining the margins of the lid by cutting a series of holes through the cortical plate with a small round bur. The holes are then joined with the use of a chisel and the cortical plate elevated away and placed in normal saline during the course of the procedure. Subsequently the lid is replaced, occasionally with stabilizing resorbable sutures. While access is unparalleled, there has been some concern over transient mandibular paraesthesia, subsequent infection or sloughing of the lid itself. There may have been undue heating of the cortical bone as the small round bur head is unlikely to have been adequately washed by coolant as it travelled through the thick osseous tissue. There has been little further reference in the literature to the bony lid approach in the past 17 years, so it appears that this technique has not been widely adopted. The subsequent introduction of the operating microscope and its attendant armamentarium has facilitated access and visualization of the mandibular molar region with a more conservative approach and may have rendered the former technique obsolete.

Size of the resected root face

Morfis et al. (50) and Kim et al. (39) have determined that the majority of unfilled lateral canals and other aspects of accessory canal anatomy are located in the apical 3 mm of the root. Thus, 3–4 mm of the apical portion of the root should be clearly exposed, at least to the buccal, mesial and distal. Following resection of the required 3 mm of root tip, there should still be good visibility of the resected root surface for the next stage of the procedure.

Gilheany et al. (51) proposed that the depth of the root-end preparation should be at least 3 mm. As a result, most root-end preparation tips, whether ultrasonic or sonic, are 3 mm in length. The osteotomy should therefore be large enough to allow such a tip to be positioned inside the crypt and engage the exposed canal in the resected root face in the long axis of the root, while the surgeon has good unimpaired visual access to the site. If osseous access has already been made to expose 3–4 mm of the root tip, there is no firm requirement to make the margins of the osteotomy larger than this, as the root-end preparation tip should fit without interference.

The other factor that will determine the outline of the osteotomy is the size and position of any soft tissue lesion surrounding the root tip or lateral opening from the root canal system. The osteotomy should be large enough to allow access to the full extent of the lesion, while retaining as much bone as possible, particularly cervical to the lesion itself. A bridge of healthy cortical plate between the gingival margin and the osteotomy is associated with a more successful outcome (Fig. 9). Indeed the prognosis is significantly poorer if no buccal bone is present over the root tissue (52–54).

Surgical curettage

The aim of curettage is to remove the periradicular soft tissue lesion that represents the apical periodontitis to allow optimal access and visualization of the apical third of the relevant root or roots. Nair (55) has character-

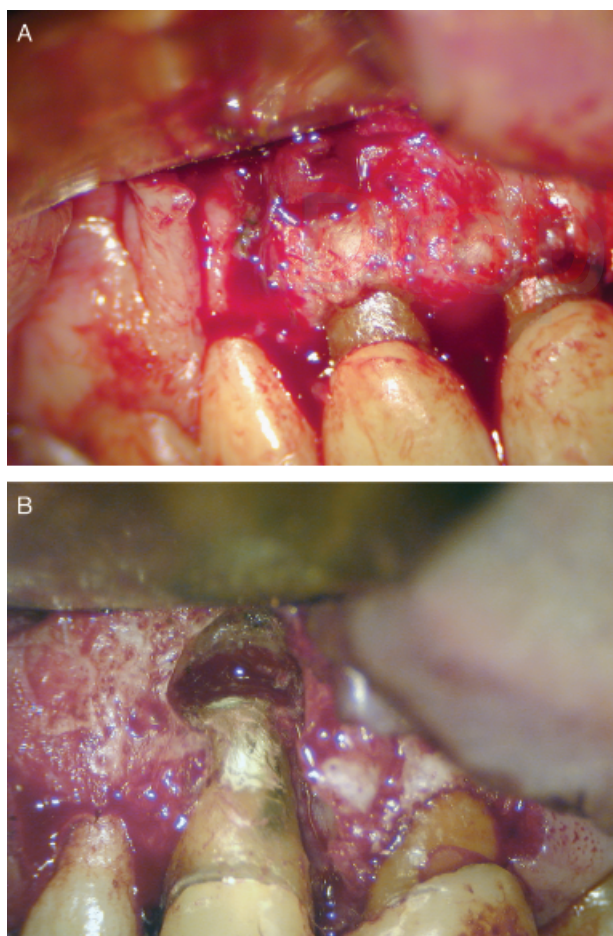


Fig. 9. (A) Example of adequate bridge of buccal alveolar bone coronal to lesion. (B) Complete absence of buccal bone in this example. Note the calculus on the root face. Prognosis is very poor.

ized this tissue as being granulomatous, predominantly infiltrated with lymphocytes, plasma cells and macrophages. The lesions may or may not be epithelialized. Additionally there may occasionally be foreign bodies such as root filling material or other forms of debris present in the periradicular area (56). However, the source of periradicular periodontitis is not the soft tissue lesion, but the presence of microorganisms and their inflammatory mediators within the canal system (57–60), and possibly in a bacterial plaque on the external root surface (61, 62). Therefore removal of the soft tissue lesion alone, whether or not it contains bacteria, will not resolve the persistent disease process. The exception to this dictate, however, may be the presence of an extraoral infection within the soft tissue lesion, caused by some species of actinomycosis or *Propionibacterium propionicum* (63–65), even when the root canal system has been successfully disinfected and sealed, or a foreign body reaction to root filling or other material. The difficulty the operator faces is that is not possible to decide clinically with any certainty the nature of the soft tissue lesion or whether it contains significant numbers of bacteria.

There has been considerable debate on the necessity of removing all this tissue during the surgical procedure. As inflammatory periradicular lesions are the body's defence response to the inflammatory mediators that egress from the root canal system, the lesion should heal if the source of these irritants is eliminated or at least is sealed off. Lin et al. (66), in a review of the literature, stated that removal of the soft tissue lesion in its entirety is considered unnecessary, as remaining tissue remnants will be incorporated into the new granulation tissue as part of the healing process. Even if an epithelial lining were present, a radicular cystic lesion would be significantly disrupted by incomplete curettage and is likely to heal. An animal study involving cats (67) compared the rate of healing following periradicular surgery where in half the cases the soft tissue lesion was not removed. There were no significant differences between the two groups. While one should always be cautious of extrapolating data from an animal model to the human, it does corroborate with information in the existing literature.

There has been less agreement on the frequency and clinical relevance of a cystic lining to the lesion. While elements of epithelium may be detected in many biopsied specimens, the lesion itself may not be a true cyst. Simon (68) originally identified two different

types of radicular cyst – true cysts that were completely enclosed in an epithelial lining, and bay cysts, later renamed pocket cysts by Nair et al. (69), where the epithelium lined cavity was open to the root canal. Nair et al. (69) analyzed 256 periradicular lesions obtained *in toto* with extracted teeth, using a meticulous step-serial section technique. They reported the incidence of true cysts as 9%. They concluded that true cysts are unlikely to resolve following non-surgical root canal treatment or retreatment, whereas pocket cysts should resolve if the inflammatory mediators within the canal system are eliminated and the system satisfactorily sealed.

Nair (56) has also reported foreign body reactions to gutta-percha, sealer, paper points and a variety of different materials such as vegetables, presumably forced into the canal and extruded through the apical foramina of teeth with severely damaged or carious coronal tissue and exposed pulp chambers, or during a period of open drainage with no coronal seal to the access cavity. Under these circumstances, if all micro-organisms and their by-products have been eliminated from the root canal system and an effective apical and lateral seal is present, apical curettage alone, including removal of the foreign body material contained within, should be sufficient to promote healing.

Because of the inability to predictably removal of all microbes and their by-products or to seal the canal system completely (70, 71), periradicular periodontitis may well persist following curettage unless the source of the infection is addressed by root resection and root-end filling. Although the surgeon may suspect extraoral infection within the soft tissue lesion, anticipate that the lesion may be a true cyst, or confirm the presence of foreign material within its confines, the exact nature of these conditions cannot be determined clinically. A final diagnosis would have to await a pathologist's histologic biopsy of the lesion. Thus there is general agreement that curettage alone is not adequate and must be accompanied by root resection and the root-end filling procedure.

Technique of curettage

This is one area of the surgical procedure that has not changed over the past decade. Typical instrumentation would include a sharp bone curette – a Lucas 86 is a popular choice – and perhaps a sharpened endodontic excavator for smaller bony crypts, a suitably curved periodontal curette such as a Columbia #13/14 and a

#34/35 Jaquette scaler (Hu-Friedy, Chicago, IL, USA) (39, 40) (Fig. 10). The soft tissue lesion is undermined by placing a sharp bone curette or large excavator at the junction of the bony crypt and the lesion itself, with the 'spoon' portion of the instrument positioned so the convex surface of the spoon faces the soft tissue. The instrument is advanced lingually and laterally, dissecting the lesion away from the walls of the crypt (Fig. 11). Once the lesion has been released from these surfaces, the curette is turned so the concave surface is in contact with the soft tissue at its lingual border. With care, the soft tissue may be released from the lingual bony wall, without piercing or fragmenting the tissue. It is generally more difficult to dissect the lesion from the root surface, to which it is firmly attached. The bone curette is no longer appropriate and the periodontal curettes should be employed to scrape the tissue away from the root – this is most difficult lingually where the operator cannot see except with the aid of micro-mirrors. The loose lesion is grasped with a pair of tissue forceps and eased buccally to aid viewing the areas where it is still attached and facilitate the last stages of the curettage, usually performed by the sharp Jaquette scaler (Hu-Friedy) in the lingual aspects of the bony cavity and on the lingual surface of the root. The complete soft tissue lesion may then be removed from the bony cavity. It should be placed immediately into a vial containing 10% neutral-buffered formalin, sealed and sent for histologic examination. Frequently, the root tip needs to be resected the required 3 mm before access is available to remove the remaining soft tissue adhering to the lingual root surface. Nevertheless, an attempt should always be made to remove the soft tissue lesion in one piece as it far more difficult to



Fig. 10. Instrumentation for curettage. (A) Lucas 86 bone curette. (B) 34/35 Jaquette scaler. (C) Colombia 13/14 periodontal curette.

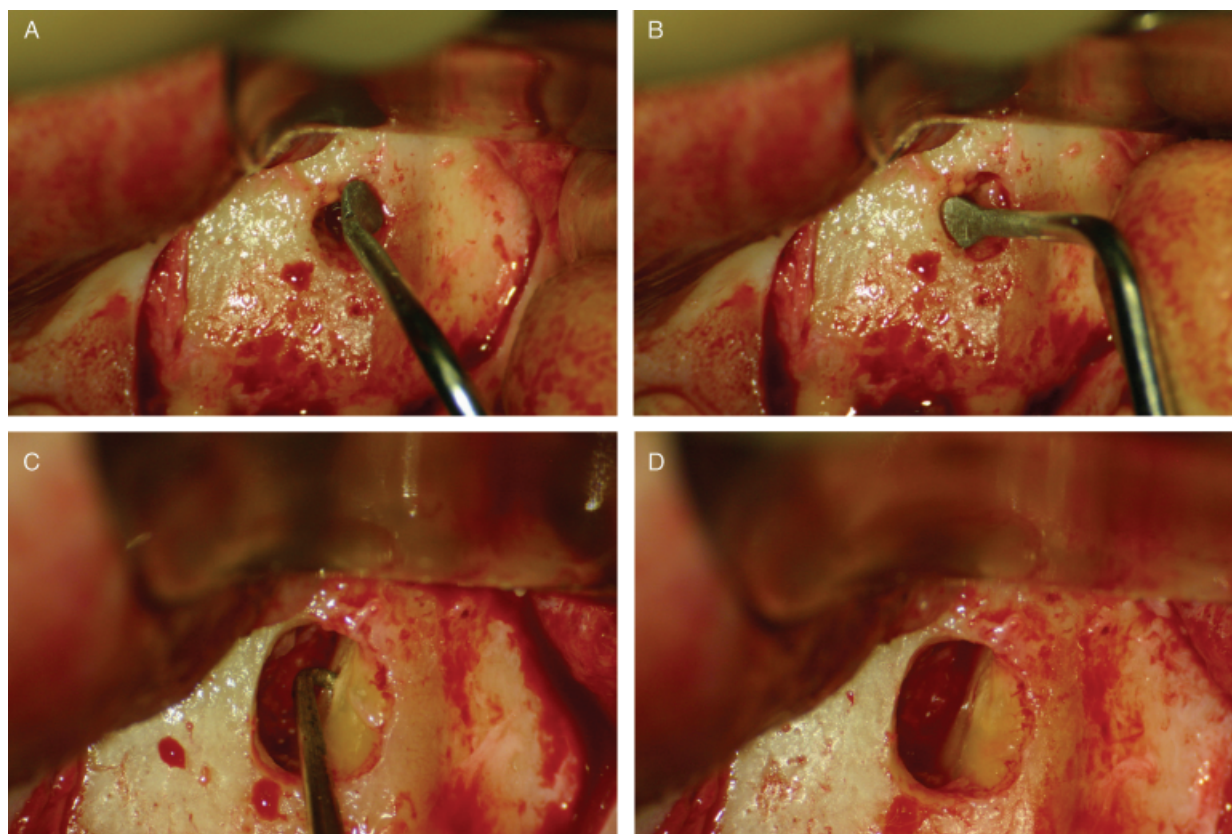


Fig. 11. (A, B) Bone curette positioned so convex surface faces soft tissue lesion, and the concave surface faces the bone walls of the crypt. (C) Lesion removed and perforation located.

dissect away shredded portions of tissue if the lesion is broken up and removed piece by piece. The pathologist's task is also made easier if a complete excisional specimen is available.

The bony crypt should then be examined under magnification to confirm that no obvious tissue tags are accessible for curettage, or that it would be inappropriate to attempt to remove them. This may be because the neurovascular bundles, or anatomical features such as the floor of the nose or the maxillary sinus, are in close proximity. Alternatively there may be inadequate local analgesia of these areas and the patient may experience pain. Despite apparently successful local analgesia during the procedure, areas of the soft tissue lesion can remain inadequately anesthetized (34, 40). Further local anesthetic solution may be injected directly into the soft tissue lesion, but, on occasions, even this procedure is not completely successful. Under all these circumstances, the remaining tissue may be left *in situ*.

Should the maxillary antral lining be involved in the soft tissue lesion, careful removal of the tissue is advocated, but again there is no necessity to curette

the last portion of the lesion if perforation of the sinus is likely. Should the Schneiderian membrane be perforated, provided no solid tissue is allowed to drop into the sinus itself, a temporary oro-antral fistula does not present a problem (72–74). The transantral buccal approach to reach the palatal root apex of a maxillary molar is not usually mentioned in the various current texts on surgical endodontics, with the exception of Arens et al. (45), presumably because of the difficulty in preventing particles of resected root tip and associated root filling material, or root-end filling material placed into the prepared cavity, from dropping into the sinus. The exposed sinus should be protected by placing a temporary barrier such as a cotton pledget in the opening. This should have a suture attached and tied to it to allow recovery of the pledget should it be inadvertently displaced into the sinus (Fig. 12).

Biopsy

Although there is unanimous agreement that the vast majority of soft tissue lesions are either granulomas or

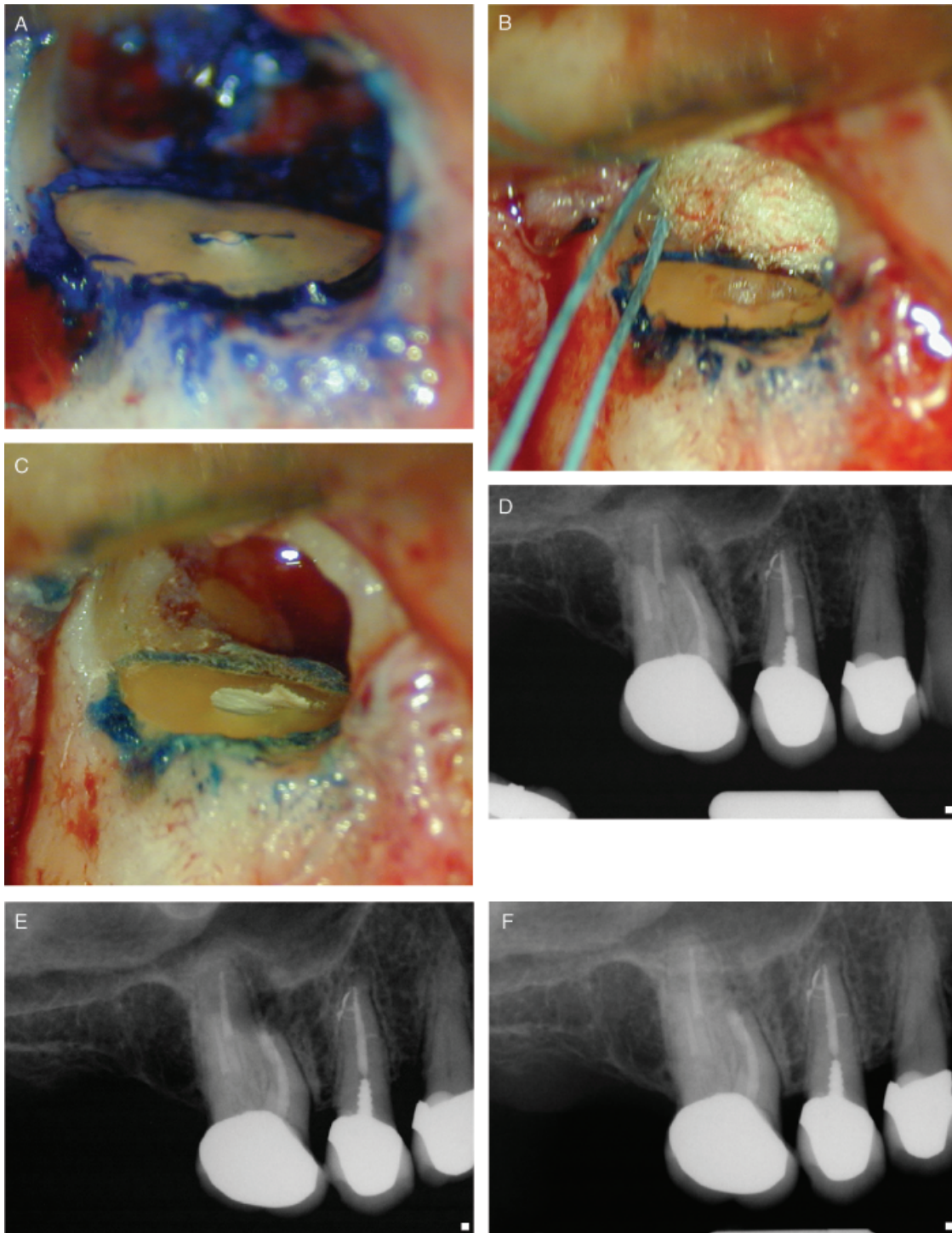


Fig. 12. (A) Maxillary antrum perforated after root resection MB root of the maxillary right first molar (#16) (Methylene blue staining). (B) Sutured cotton pledget placed in fistula. (C) Pledget removed after root-end filling placed. (D) Periapical radiograph of the same case – note MB root apex not apparently in close proximity to lining of antrum. (E) Post-root-end filling view. (F) One-year follow-up indicating healing, despite the temporary oro-antral fistula.

radicular cysts, any soft tissue lesion removed during the surgical procedure should be submitted for biopsy. However, this view was challenged by Walton (75) who argued that, provided an accurate diagnosis was made

before surgery was initiated, the identity of the lesion should be known and that routine biopsy was therefore unnecessary and only undertaken if a lesion of non-odontogenic origin was suspected. Peters & Lau (76),

in a recent review of histopathologic examination to confirm the diagnosis of periapical lesions, stated that diagnoses that identified a lesion to be other than a granuloma or radicular cyst to be in the order of 0.7–5.0% of all periapical biopsies, but that there were no data on the frequency with which soft tissue lesions are submitted for histologic examination. They drew attention to numerous case reports in the literature describing the biopsy of lesions suspected, or provisionally diagnosed, as being inflammatory lesions of endodontic origin that have proved otherwise. There are several cystic lesions, which are not of such origin, including nasopalatine duct cysts, lateral periodontal cysts and contiguous residual cysts. The most aggressive of these lesions is the odontogenic keratocyst (OKC). Shears (77) determined that 10% of all jaw cysts in a sample of 2616 lesions submitted for examination were OKCs, although Stockdale & Chandler (78) encountered only one such example in a review of 1108 cases of periapical lesions. The OKC may be mistaken radiographically for a lesion of endodontic origin or a lateral periodontal cyst (79, 80). The relevance of this particular cyst relates to the extensive bony expansion and root resorption associated with this lesion, as well as the possibility of recurrence and, very rarely, the development of squamous cell carcinoma arising in an OKC.

Peters & Lau (76) also considered case reports of benign aggressive lesions such as central giant-cell granuloma, a lesion of varying and unpredictable progression, which may again mimic a periradicular lesion of endodontic origin (81). Other lesions reported included ossifying fibroma (82), Pindborg tumor (83), Langerhans cell disease (84), osteoblastoma (85) and central odontogenic fibroma (86).

The possibility of extraradicular bacterial infection has already been mentioned and the incidence of periapical actinomycosis in particular may not be as rare as previously thought. One review of the literature by Sakellariou (63) described some 45 case reports of the infection. A recent study (64) reported that the incidence of actinomycotic colonies located in lesions submitted for biopsy with a clinical diagnosis of granuloma or radicular cyst was 1.8% – uncommon but not rare! Treatment included a short course of antibiotic therapy to supplement the surgical procedure of curettage, root resection and root-end filling.

The major concern, however, is a misdiagnosis of a malignant neoplasm. Case reports abound in the literature and represent some 12% of documented

cases (86–91). One paper alone presented seven cases, all initially treated for presumed periapical pathosis that were subsequently found to be neoplastic (92). While the level of evidence is obviously low – virtually all the papers discussed are just case reports – the inference is clear. Although careful clinical diagnosis may usually provide the correct histological diagnosis, there are many cases where such diagnosis has been shown to be mistaken. The limitations of special tests to assess pulp vitality and of radiographic interpretation are well known, quite apart from the incidence of less than thorough clinical examination or simple human error. Kuc et al. (83) examined the clinical and histopathologic diagnoses of 805 sequentially submitted periapical biopsy specimens. They concluded that in 5% of cases the histopathologic diagnosis added to or changed the original clinical interpretation, although they did warn against general extrapolation of this information.

In view of the possible serious consequences of a misdiagnosis, authors overwhelmingly agree that soft tissue lesions excised during surgical endodontic procedures should be sent for histopathologic examination (33–35, 38–40). The current AAE guidelines (93) also concur that a biopsy is indicated ‘when an adequate amount of tissue or foreign material can be removed from the periradicular surgical site for histopathologic examination.’

Conclusion

Unlike many aspects of periradicular surgery, the stages of osseous access and curettage have not altered significantly in the past decade or two. The literature is of a low level of evidence and techniques described in texts generally anecdotal. However, the availability of the operating microscope has provided vastly improved magnification and co-axial lighting to facilitate and refine these procedures. In particular, bone removal and root tip location with high-speed rotary instrumentation, and awareness of anatomic structures in close proximity to our surgical cures, have become easier, safer and more predictable.

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